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AN EXCEPTION TO BATESON'S RULE OF SECONDARY SYMMETRY.

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In the summer of 1917, while employed by the Biological Board of Canada in a Dominion Lobster Hatchery at Bay View, N. S., my attention was called to an abnormal lobster caught by a local fisherman in the adjoining waters of Pictou Harbor. The lobster was a male and measured $7\frac{1}{2}$ inches from rostrum to telson. The abnormality consisted of a double extra claw on the right cheliped, resulting in a condition of incomplete triplication. The presence of the extra parts on the right side did not appear to greatly handicap the animal which, when placed in one of the hatchery tanks, moved about freely. Other abnormalities somewhat similar have been described for the lobster by Faxon ('81), Emmel ('07) and Cole ('10).

DESCRIPTION.

The "triple" chela of the right side consisted of a small "nipper" and a double extra "crusher," while the corresponding appendage of the left side was large, normally developed and of the nipping type. The small "nipper" of the monster claw apparently represented the primary member of the group and, with the exception of the meropodite (*M.*), was normal in all its segments. Arising from the posterior (morphologically ventral) surface of this meropodite was the double extra claw.

The first segment of the right chela, the ischiopodite (*Is.*) was not exceptionally large and presented no evidence of distortion; but in the meropodite, as already noted, the effect of the abnormality in the appendage was very evident. This segment was of normal width proximally but broadened out rapidly distally and terminated in two diverging branches (*M.*, *M.'* + *''*). On *M* was borne the small primary claw while *M.'* + *''* carried the much larger abnormal structure.

On examining the more posterior prong of the compound meropodite, we find that the next distal segment, *i.e.*, the extra carpopodite ($C.' + ''$) is morphologically double. It is more than twice as large as the corresponding segment ($C.$) of the primary claw and bears on its upper surface two groups of spines separated by a shallow longitudinal groove. On the end of the massive carpopodite is the large double protopodite ($P.' + ''$). This segment is incompletely divided, with the separation extending only as far as the region on a level with the bases of

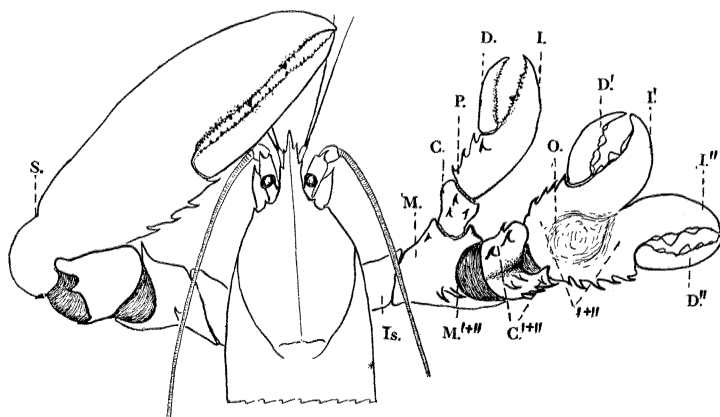


FIG. 1. (One half natural size.) Male lobster possessing an abnormal right chela consisting of a primary nipping claw plus a double extra "crusher." $C.$, primary carpopodite; $C.' + ''$, double extra carpopodite; $D.$, primary dactyl; D', D'' , two extra dactyls; $I.$, primary index; I', I'' , two extra indices; $Is.$, ischiopodite; $M.$, primary portion of meropodite; $M.' + ''$, extra portion of meropodite; $O.$, conical protuberance on double protopodite; $P.$, primary protopodite; $P.' + ''$ (P omitted in reproduction), double extra protopodite; $S.$, scar on left chela.

the indices (I', I''). Opposing the indices are two well developed movable dactyls (D', D''). The two partially separated chelæ are almost exact mirror images of each other. The dactyls and indices are practically identical and the dentition of both consists of heavy tubercle-like teeth. There are no tactile hairs.

Each segment of the double extra claw was decidedly larger than the corresponding portion of the primary claw, but the entire "triple" appendage barely equalled the left nipping claw in weight. The long axes of the double appendage and primary

appendage were in one plane and all three dactyls moved to meet their opposing indices in this plane.

Another point of considerable interest is the color relation of the extra portions. In the double extra protopodite and the two extra dactyls the pigmentation was completely reversed, giving as a result a light colored upper and a densely pigmented lower surface. A peculiar conical protuberance present on the light upper surface of the double protopodite was practically free from pigment.

THEORETICAL CONSIDERATIONS.

The present example, like most abnormal crustacean appendages, falls into the category established by Bateson ('94), "in which the extra limb or extra parts of a limb are themselves morphologically double," but unlike the others it does not conform to the rules of secondary symmetry formulated by the same author. According to these rules the normal appendage and the extra parts lie in the same plane and "the nearer of the two extra appendages is in structure and position formed as the image of the normal appendage in a plane mirror placed between the normal appendage and the nearer one, at right angles to the plane of the three axes; and the remoter appendage is the image of the nearer in a plane mirror similarly placed between the two extra appendages" (p. 479).

In the case under discussion the pair of extra chelæ are mirror images of each other but the appendage nearer the primary claw is not, as the rules provide, a mirror image of the latter. Moreover, it does not appear possible to explain this exception to the rules of secondary symmetry by a reference to torsion. Emmel ('07) and Cole ('10) were unable to explain apparent exceptions to Bateson's rules by making allowances for changes in position due to possible torsion. It has previously been pointed out that the coloration of the abnormal double structure was completely reversed, but even if the extra segments were rotated so that the dark surface became uppermost the relations of the claws as regards secondary symmetry would remain unchanged since the double extra claw is bilaterally symmetrical.

The specimen here described while exhibiting many points of

resemblance to the abnormal chelipeds figured by Emmel ('07, Pl. 2, Fig. 5) and Cole ('10, Figs. 1, 2) also presents several novel features. The degree of "triplication" of the claw is less than that seen in Emmel's specimen but greater than that described by Cole. In the former, the abnormal processes, consisting of a double carpopodite, two protopodites and two dactyls arose from the meropodite. In the latter, the abnormal structure, two extra indices and a double extra dactyl, was borne on the normal protopodite. In Faxon's specimen ('81) the morphological character of the extra branch which is borne on the forked meropodite is questionable. Faxon himself does not believe that the structure is double but Bateson ('94) is inclined to regard it as being morphologically double. Furthermore both Emmel and Cole found that the conditions in their "triple" claws illustrate the rules of secondary symmetry almost diagrammatically, *i.e.*, when allowance was made for shifting due to torsion.

In the two chelæ described by Emmel and Cole the two extra claws were of the same character as the primary claw, "crushers." In my specimen the primary claw is a "nipper" while the two extra claws are of the crushing type with well-developed tubercle-like teeth. This condition is of special significance, when we recall that the claw of the opposite side is also of the nipping type. In other words, we have a lobster with the "great" claws symmetrical with reference to each other, besides bearing on the meropodite of the right a double extra "crusher."

Emmel ('07) finds the pigmentation reversed on one of the extra claws but is able to explain this abnormal condition by a reference to torsion. The case which I am describing does not admit of such an explanation. The cause of the abnormality is unknown. No scars were to be found on the "triple" claw, but on the protopodite of the appendage of the opposite side a definite scar (*S*) was present. There were no further evidences of mutilation.

The results obtained by Harrison ('17) with transplantation of limb buds in *Amblystoma* larvæ suggest that there may possibly be some direct relation between the reversal of pigmentation and the doubling of the extra appendage. Harrison found that in

transplantations in which the limb buds were inverted, a certain percentage gave rise to double or twin limbs, one being a mirror image of the other. In a few cases there were still further duplications so that more or less complete triple limbs resulted, having approximately the same relations as found by Bateson in the Arthropoda.

In the lobster just described, two facts were noted; first, the extra parts are double and second, their pigmentation is reversed indicating an inversion of the double portion of the triple appendage. Furthermore, it is generally conceded that most abnormal and duplicated appendages among Crustacea are the result of regenerative processes. Both Reed ('04) and Emmel ('07) have found that abnormalities can be produced experimentally by mutilating either the proximal stump or the developing limb bud. It is conceivable then that the triplication found in the present instance may be due to regeneration following injury. In the course of regeneration the growing bud may have been also injured so as to cause the development of an extra process (Emmel, '07, pp. 114-115), and this process may have had its dorso-ventral orientation reversed either at the time its development was initiated or at some later date.

Keeping the above statements in mind it therefore becomes possible to elaborate a more or less satisfactory hypothetical explanation of the triple chela. First, there may have been an injury to a normally developed crushing claw, followed by autotomy. Later the developing bud may have been injured, resulting in the appearance of an extra bud on the surface of the primary one. As a consequence of the injury, the primary bud did not develop as a crushing claw but as a small "nipper." (Sufficient evidence has been adduced by Emmel in 1907, Figs. 24 to 31, to prove that abnormal symmetrical claws in lobsters do arise through regeneration following mutilation.) The extra bud, due to mechanical displacement of its tissue at the time of the first injury, or as a result of a subsequent accident, has had its dorso-ventral orientation reversed, causing the development of twin crushing claws which are mirror images of each other.

SUMMARY.

1. An abnormal lobster cheliped is described in this paper. The abnormality consists of a double extra crushing claw arising from the meropodite of a claw of the nipping type.

2. The conditions found here are shown to present an exception to Bateson's rules of secondary symmetry.

3. The primary member of the so-called triple claw was found to be of the same character as the corresponding appendage of the opposite side, furnishing an exception to the normal condition of asymmetry.

4. Pigmentation was reversed in the double extra claw.

5. There is some evidence in favor of the view that there is a definite relation between the reversal of pigmentation and the doubling of the extra appendage.

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